LANDFILL COVER REVEGETATION AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

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ABSTRACT

In 1998, a revegetation project was begun on a landfill cover at the Rocky Flats Environmental Technology Site near Golden, Colorado. After final contouring of the landfill cover, the area was broadcast seeded with native species including: *Agropyron smithii*, *Bouteloua gracilis*, *Buchloe dactlyoides*, *Andropogon gerardii*, *Andropogon scoparius*, and *Linum perenne*. In May 1999, the cover was treated by helicopter with Tordon22K® to control the noxious weed, *Centaurea diffusa*. During 2001, vegetation cover and species richness was measured along five 50-m transects. A total of 25 species (56% native) were recorded along the transects. Total vegetation cover averaged 71%. Basal cover was dominated by rock (41.2 %), litter (28.6 %), bare ground (23 %), and vegetation (7.2 %). Graminoids and forbs comprised 92 % and 8% of the total relative cover, respectively. The dominant plant species were *B. gracilis*, *A. smithii*, *B. dactlyoides*, *B. curtipendula*, all native, perennial grass species. Total relative native species cover on the landfill cover was 89 percent with 85 percent of this coming from native grasses (Table 2). Graminoid cover was dominated by warm-season species (74% relative foliar cover). Only 18% of the relative foliar cover came from cool-season graminoids. Compared to the surrounding native prairie plant communities, rock and bare ground cover amounts remain high and litter cover is low. Total native species cover is considerably higher on the revegetation area compared to the surrounding prairie. Thus far the revegetation effort has proven very successful and has required little maintenance other than weed control.

INTRODUCTION

A sanitary landfill cover (approximately 21 acres) at the Rocky Flats Environmental Technology Site was revegetated with native species in spring 1998 to provide a vegetative cover and prevent wind and water erosion. Monitoring was conducted during fall 2001 to evaluate the revegetation effort and qualitatively assess the condition of the vegetation on the landfill cover.

BACKGROUND INFORMATION

In May 1998, after final contouring, a native seed mix was broadcast on the landfill cover (Table 1). Biosol® fertilizer was added to the surface of the to provide some basic plant nutrients for growth because no topsoil was available. After seeding, straw mulch was crimped in and then hydromulched with a tackifier and wood mulch to prevent wind and water erosion. In May 1999, the landfill cover was sprayed with Tordon 22K® by helicopter to control the noxious weed diffuse knapweed (*Centaurea diffusa*) that had become a problem on the cover.

Table 1. Seed Mix for Landfill Cover

Scientific Name	Common Name	Application Rate (PLS lbs/ac)
Agropyron smithii	Western Wheatgrass	12.0
Bouteloua gracilis	Blue Grama Grass	8.0
Buchloe dactlyoides	Buffalo Grass	8.0
Andropogon gerardii	Big Bluestem	8.0
Bouteloua curtipendula	Side-Oats Grama Grass	8.0
Andropogon scoparius	Little Bluestem	8.0
Linum perenne	Blue Flax	4.0
Total PLS per acre application		56.0

PLS = pure live seed

SAMPLING METHODS

In late September 2001, species composition was measured on the landfill cover using a modified line-intercept methodology. Five 50-m transects were established across the cover parallel to some methane monitoring transects for which the data was also being gathered (Figure 1). Endpoints of all transects were recorded using global positioning system (GPS) equipment for entry into the Site geographic information system (GIS).

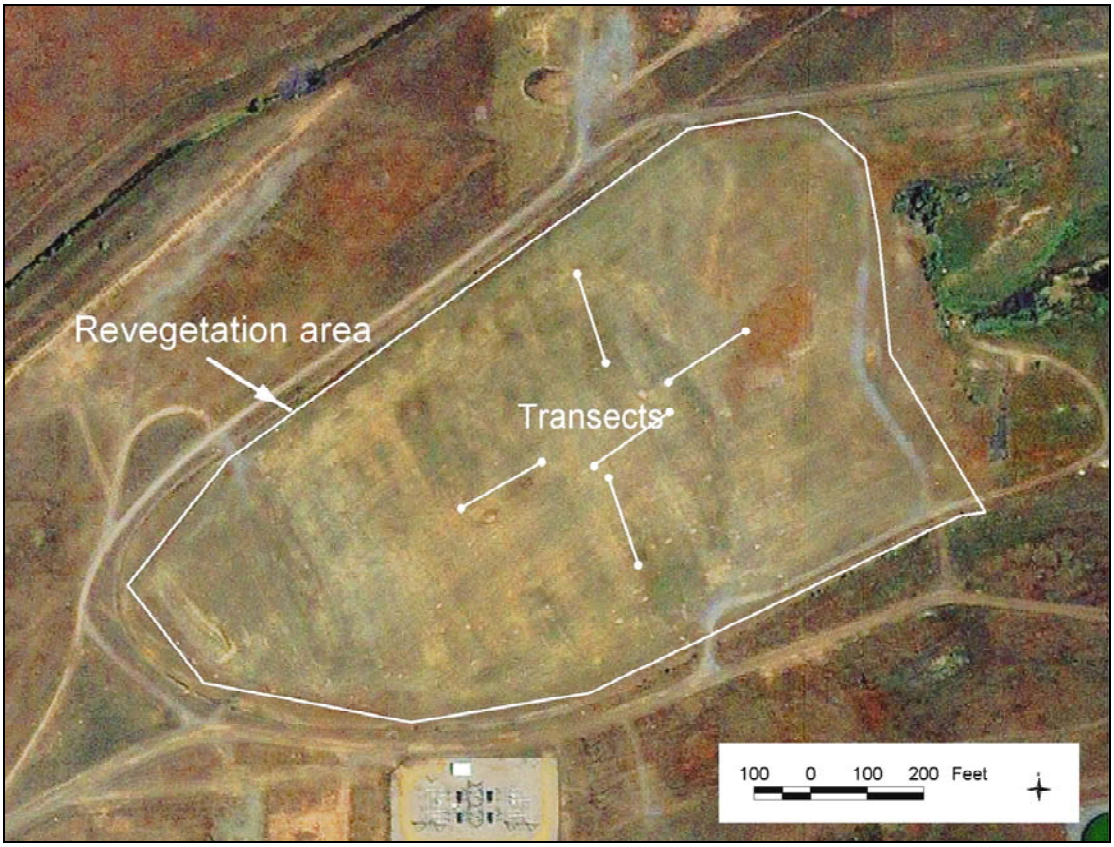

Figure 1. The landfill cover at Rocky Flats is the lighter area in the center of the photograph. The five transects were located along some methane monitoring transects that were also being sampled.

Basal cover and foliar cover were estimated using a modified line-intercept method along each 50-m transect. A 2-m-long, 6-mm-diameter rod was dropped vertically at 50-cm intervals along the length of each transect to record a total of 100 intercept points. Two categories of hits were recorded, basal and foliar. Basal cover hits were recorded based on what material was hit by the rod at the ground surface. Hits could be vegetation (live plants), litter (fallen dead material), rock (pebbles and cobbles greater than the rod diameter), bare ground, or water, in that order of priority based on the protection from erosion provided by each type of cover. Vegetation hits were identified to species. Basal vegetation hits were recorded only if the rod was touching the stem or crown of the plant where the plant entered the ground. Foliar vegetation hits (defined as a portion of a plant touching the rod) were recorded by species in three categories as defined by height and growth form. The topmost hit of each growth form was recorded. The growth forms measured were herbaceous, woody <2 m in height, and woody >2 m in height.

Additionally, a single photograph was taken of each transect to visually document the condition of the transects. Photographs were taken from near the 0-m end of the transect looking toward the 50-m endpoint. A placard was placed in the photograph against the 0-m endpoint to provide the site and transect number, and date.

Cover data were summarized for both basal and foliar cover by combining the data from the five transects. Foliar data was summarized by species and by various life form categories. Basal cover data are reported as total percent cover of vegetation, litter, rock, and bare ground. Foliar cover data are reported as frequency, absolute cover, and relative cover for each species encountered. Frequency from the cover data was defined as the percent of line-intercept transects on which a species occurred, out of the total possible five sampled at each site. Absolute foliar cover was the percentage of the number of hits on a species out of the total number of hits possible at a site (500). This value is the actual cover of a species. Relative foliar cover was the number of hits a species had relative to the total number of vegetative hits recorded per site (i.e., the percent of total vegetative cover [100 percent] represented by the species). Both absolute and relative foliar cover values are presented as means. Comparisons were made to previously sampled native grassland locations at the Site.

RESULTS

The monitoring results are presented in Table 2. A total of 25 species were recorded along the transects in 2001. Of these, 56 percent were native species. Total vegetation foliar cover was 71.2 percent. Basal or ground cover on the landfill cover was dominated by rock (41.2 percent), litter (28.6 percent), bare ground (23 percent), and vegetation (7.2 percent). The vegetation on the landfill cover was dominated by graminoid species that comprised approximately 92 percent of the total relative foliar cover. The dominant plant species were blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), buffalo grass (*Buchloe dactlyoides*), and side-oats grama (*Bouteloua curtipendula*), all of which are native, perennial grass species. Total relative native species cover on the landfill cover was approximately 89 percent with 85 percent of this coming from native grasses. Graminoid cover was dominated by warm-season species which comprise approximately 74 percent of the total relative foliar cover. Approximately 18 percent of the total foliar cover came from cool-season graminoids. Forbs accounted for only approximately 8 percent of the total foliar cover. A Shannon-Weaver diversity index value of 0.88 was calculated from the relative foliar cover data.

Table 2. Landfill Cover Foliar Cover Data Summary

Scientific Name	Speccode	Growth Form	Native	Cool/ Warm Season	Frequency	Percent Absolute Cover	Percent Relative Cover
Centaurea diffusa Lam.	CEDI1	F	N		40	1.2	1.7
Dyssodia papposa (Vent) Hitchc.	DYPA1	F	N		20	0.2	0.3
Melilotus alba Medic.	MEAL1	F	N		20	0.2	0.3
Melilotus officinalis (L.) Pall.	MEOF1	F	N		60	1.8	2.5
Plantago lanceolata L.	PLLA1	F	N		20	0.2	0.3
Ambrosia psilostachya DC.	AMPS1	F	Y		100	1.4	2.0
Grindelia squarrosa (Pursh.) Dun.	GRSQ1	F	Y		40	0.6	0.8
Helianthus annuus L.	HEAN1	F	Y		40	0.4	0.6
Bromus japonicus Thunb. ex Murr.	BRJA1	G	N	C	20	1.2	1.7
Bromus tectorum L.	BRTE1	G	N	C	60	1.6	2.2
Dactylis glomerata L.	DAGL1	G	N	C	20	0.2	0.3
Schedonnardus paniculatus (Nutt.) Trel.	SCPA2	G	N	C	20	0.4	0.6
Echinochloa crusgallii (L.) Beauv.	ECCR1	G	N	W	20	0.2	0.3
Setaria viridis (L.) Beauv.	SEVI1	G	N	W	40	0.8	1.1
Agropyron smithii Rydb.	AGSM1	G	Y	C	100	9	12.6
Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	G	Y	C	20	0.2	0.3
Andropogon gerardii Vitman	ANGE1	G	Y	W	60	1	1.4
Andropogon scoparius Michx.	ANSC1	G	Y	W	40	0.4	0.6
Bouteloua curtipendula (Michx.) Torr.	BOCU1	G	Y	W	100	6	8.4
Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	G	Y	W	100	33.2	46.6
Buchloe dactyloides (Nutt.) Engelm.	BUDA1	G	Y	W	100	7	9.8
Panicum capillare L.	PACA1	G	Y	W	40	0.8	1.1
Panicum virgatum L.	PAVI1	G	Y	W	40	0.4	0.6
Sporobolus asper (Michx.) Kunth	SPAS1	G	Y	W	40	1.4	2.0
Sporobolus neglectus Nash	SPNE1	G	Y	W	40	1.4	2.0
Total foliar cover						71.2	100.0
Total forb cover						6	8.4
Total native forb cover						2.4	3.4
Total non-native forb cover						3.6	5.1
Total graminoid cover						65.2	91.6
Total native graminoid cover						60.8	85.4
Total non-native graminoid cover						4.4	6.2
Total native cover						63.2	88.8
Total non-native cover						8	11.2
Total warm-season graminoid cover						52.6	73.9
Total cool-season graminoid cover						12.6	17.7

Absolute cover = Absolute foliar cover is the percentage of the number of hits on a species out of the total number of hits possible (500).
Relative cover = Relative foliar cover was the number of hits a species had relative to the total number of all vegetative hits recorded per site (i.e., the percent of vegetative cover the species represented).
All cover values presented are means (n = 5).
Native categories: Y = Native, N = Non-Native
Form categories: C = Cactus, F = Forb, G = Graminoid
Cool/Warm Season categories: C = Cool season species, W = Warm season species

DISCUSSION

The revegetation effort on the landfill cover at the Site has done very well in the three years it has been in place (Figure 2). In 2001, the vegetation on the landfill cover was predominantly native, warm-season, perennial, graminoid species. It is dominated by blue grama (which accounts for almost half the total relative foliar cover [46.6 percent] of the cover), western wheatgrass, buffalo grass, and side-oats grama, all of which were planted species in the seed mix. Other seeded species that accounted for smaller cover amounts included big bluestem (*Andropogon gerardii*) and little bluestem (*Andropogon scoparius*). Compared to native plant communities at the Site, the amount of native species cover is already equal to

or greater than that found on the native grasslands (K-H, 2001). The vegetation on the landfill cover has the greatest similarity to that of the mesic mixed grassland, a blue grama/western wheatgrass dominated native community at the Site. The health and vigor of these grasses on the landfill cover appeared good, as indicated by the size of the plants and amount of flowering observed during sampling. No sign of chlorosis or wilting was observed. Although total vegetation cover on the cover was approximately 15-20 percent below that of the native grasslands in an average year, the plants have begun to spread and fill in the spaces between the initial establishment locations. The overall vegetation cover should continue to increase over the next few years and form a solid stand of native vegetation.

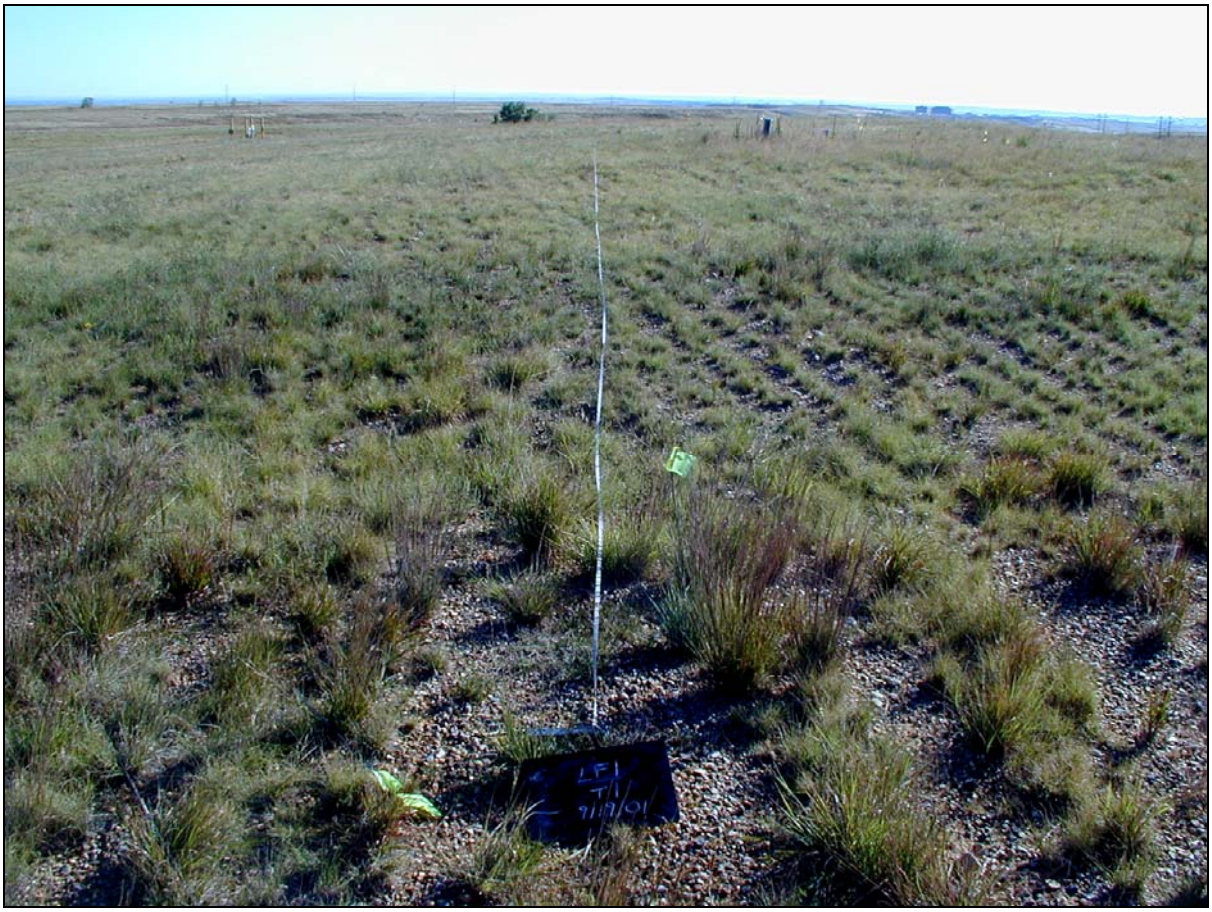

Figure 2. Vegetation on landfill cover three years after seeding. The area is dominated by native, warm-season graminoid species like blue grama, western wheatgrass, buffalo grass, and side-oats grama.

Species diversity on the landfill cover is still somewhat low (Shannon-Weaver index = 0.88) compared to the native mesic mixed grassland which in 2000 ranged in diversity from 0.984 to 1.276 at three different locations. However, the lower diversity is not unexpected given that only one forb species was in the seed mix planted on the landfill cover and considering that the landfill cover was also sprayed with Tordon 22K®, a broadleaf herbicide, used to control diffuse knapweed, in May 1999. Eventually more forbs may immigrate onto the cover, increasing diversity. Currently noxious weeds, mainly diffuse knapweed, were only noticed at a few spotty locations and with continued control should remain low in abundance.

Ground cover on the landfill cover was dominated by rock. The amount of rock cover (41.2 percent) and bare ground cover (23 percent) is considerably higher than that found on the mesic mixed grassland at the Site. In 2000, at three locations on the mesic mixed grassland, rock cover ranged from 8.4 to 23 percent while bare ground cover varied from 2.6 to 9.2 percent. Much of this is due to the low level of litter cover currently present on the landfill cover (28.6 percent), which is far below that on the native prairie (64 to 79 percent in 2000). Because unvegetated areas still exist between many of the individual plants and the revegetation effort is only three years old, only a small amount of dead plant litter has built up on the ground surface. This will change as the vegetation continues to grow, produce litter, and expand into the spaces between the original plants.

At a few locations patches of taller vegetation were present on the landfill cover where a higher component of taller growing native plant species, such as big bluestem, little bluestem, and side-oats grama, along with taller weed species such as yellow and white sweet clover (*Melilotus officinale* and *Melilotus alba*) were growing. All seeded species, with the exception of blue flax (*Linum perenne*), were recorded along the transects. The blue flax was observed on the cover, just not along the monitored transects.

The rooting depth of some of the plants was observed at four holes dug for soil samples on the landfill cover. The maximum depth to which roots were observed at these holes was approximately 30 cm (12 in), with most being observed within the top 15 cm or so. It is likely that the plant roots actually go deeper than this, but at most of the holes it was rare to find a plant growing right at the edge of the hole.

CONCLUSIONS

The revegetation of a landfill cover at the Rocky Flats Environmental Technology Site has been very successful. Seeded in 1998, by 2001 the cover is now dominated by native, warm-season, perennial, graminoid species. The vegetation appears healthy and thriving based on the size of the plants and the flowering observed during the monitoring fieldwork. Although rock and bare ground cover remains higher than that found on the native grassland, the native species are filling in the spaces between plants and should in time form a solid stand of vegetation across most of the cover. Weed control will continue to be necessary to keep competition from noxious weeds low and allow the native species to expand their range. Thus far these results suggest a very successful revegetation project.

LITERATURE CITED

K-H. 2001. 2000 Annual vegetation report for the Rocky Flats Environmental Technology Site. Kaiser-Hill Company, LLC, Rocky Flats Environmental Technology Site, Golden, CO.